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Evaluation of Southern Ocean sea ice thickness in reanalyses

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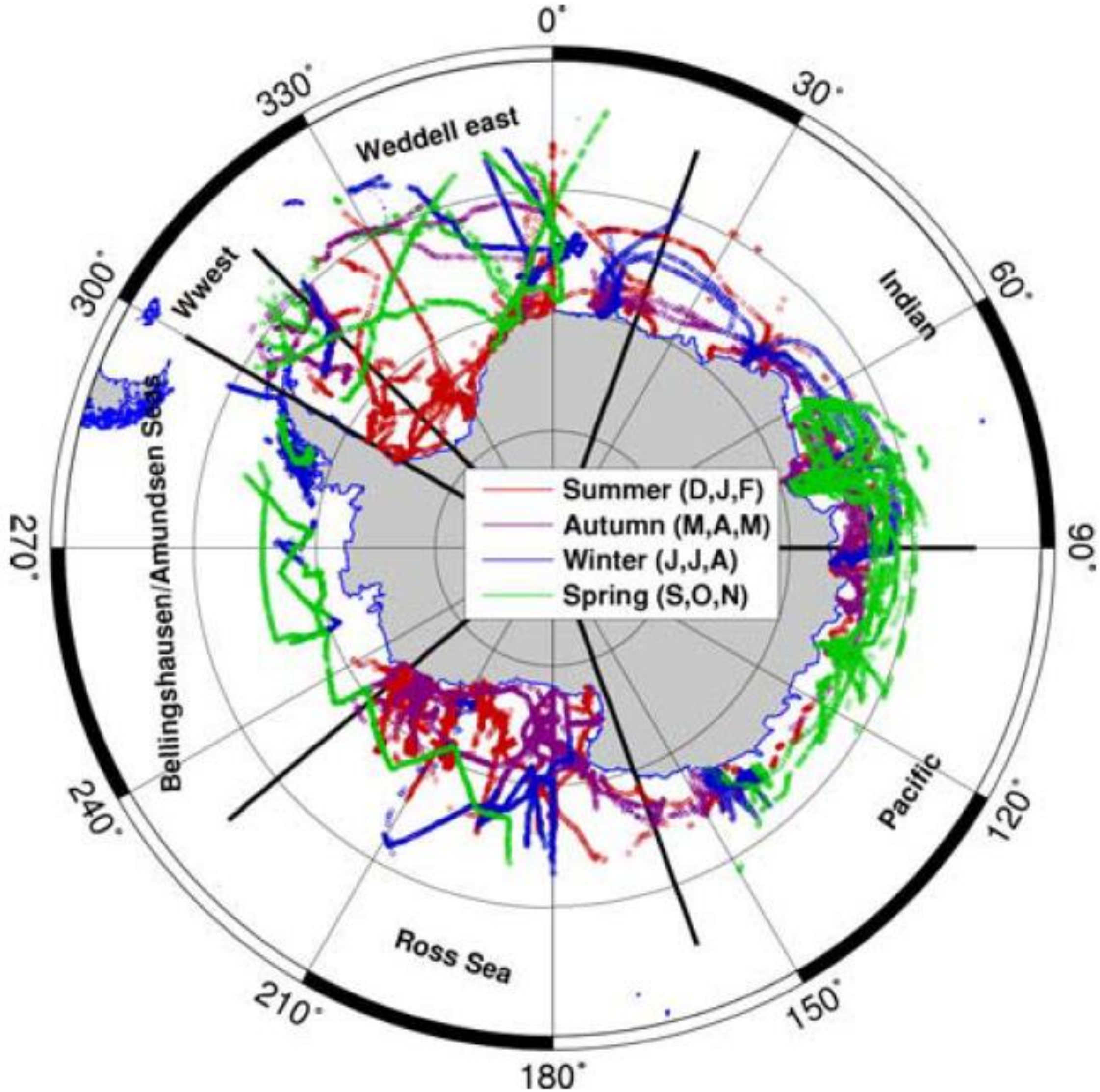
EOS-COST Meeting,
Helsinki, Ffnland
23-24 March, 2016

ASPeCt Southern Ocean sea ice thickness data: sparse but valuable



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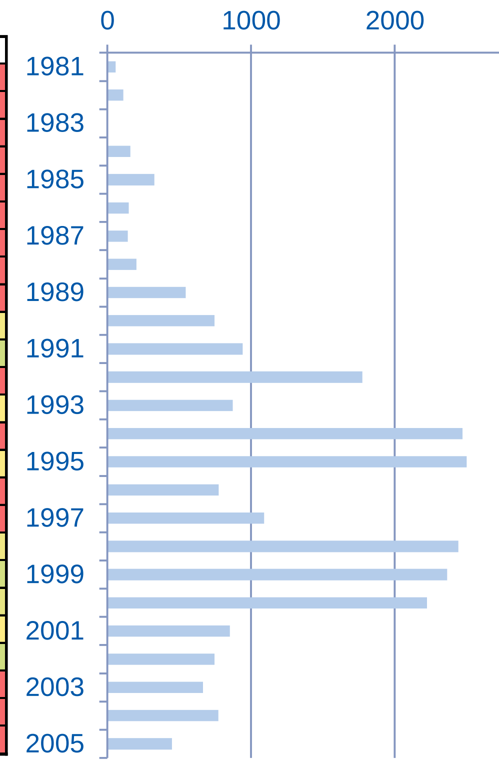
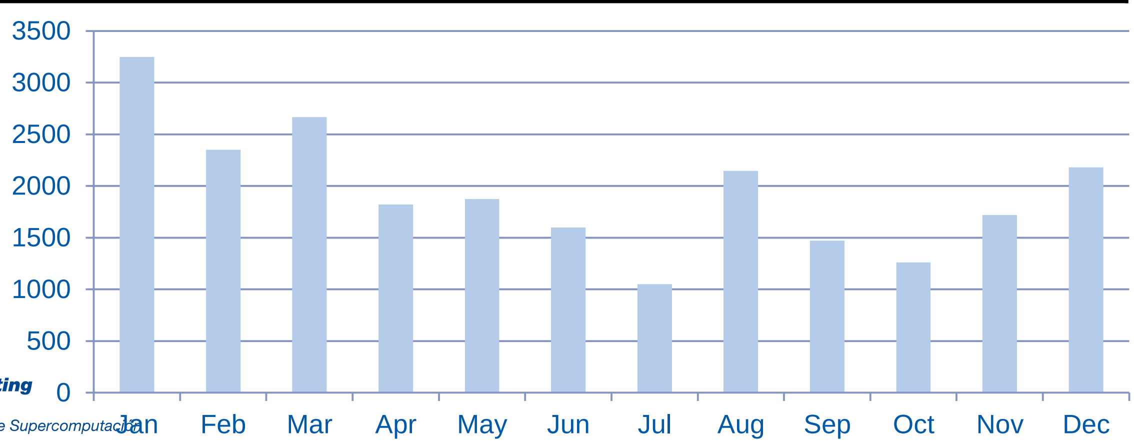
[Worby et al., JGR, 2008]

ASPeCt Southern Ocean sea ice thickness data: sparse but valuable

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	0	59	0	0	0	0	0	0	0	0	0	0
1982	0	49	62	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	25	135	0	0	0	0	0	0	0	0	0
1985	0	0	158	44	34	30	39	23	0	0	0	0
1986	0	1	149	0	0	0	0	0	0	0	0	0
1987	0	142	0	0	0	0	0	0	0	0	0	0
1988	0	87	1	0	0	0	0	0	0	69	46	0
1989	0	36	116	0	0	0	0	0	147	246	0	0
1990	0	100	511	0	0	0	0	0	0	0	0	135
1991	53	0	0	0	0	0	0	0	0	0	368	520
1992	68	310	37	315	580	238	0	0	0	72	154	0
1993	141	43	86	186	21	0	0	63	162	132	12	28
1994	197	111	141	507	51	0	164	196	575	313	216	0
1995	4	64	166	640	456	173	21	551	220	0	160	45
1996	0	0	0	0	76	507	192	0	0	0	0	0
1997	73	63	0	0	101	397	321	0	0	137	0	0
1998	531	313	214	63	556	173	31	0	0	0	393	168
1999	452	476	75	0	0	81	148	581	0	0	75	477
2000	1666	245	0	0	0	0	0	0	0	0	38	275
2001	11	44	0	0	0	0	103	341	183	112	38	21
2002	0	0	0	0	0	0	0	200	36	0	0	511
2003	27	0	396	33	0	0	0	0	64	147	0	0
2004	0	114	372	33	0	0	0	0	0	34	219	0
2005	27	69	47	0	0	0	31	191	85	0	0	0





[data: Worby et al., JGR, 2008]

Assessment of two reanalyses

	ORAP5	GECCO2	Massonnet et al. 2013
Long name	Ocean ReAnalysis, Pilot, version 5	German contribution of the Estimating the Circulation and Climate of the Ocean project	Ensemble sea ice data assimilation
Reference	Zuo et al., Clim. Dyn., 2015	Köhl, Q.J.R. Met. Soc., 2015	Massonnet et al., Oc. Mod., 2013
Period	1979-2012	1948-2011	1980-2008
Resolution	ORCA025L75 (~0.25°)	0.3 – 1°	ORCA2 (~2°)
Ocean & ice model	NEMO – LIM2	MitGCM	NEMO-LIM2
Data assimilated	EN3 T & S, AVISO SLA, SIC, OSTIA SST	EN4 T&S, AVISO SLA, HadISST, WOA clim T&S, GOCO MDT	OSI-SAF SIC
Method of assimilation	3D-Var FGAT, static BCM	4D-Var	EnKF
Atmospheric forcing	ERA-Interim	NCEP-1	NCEP

The ensemble Kalman filter is a forecast-analysis method

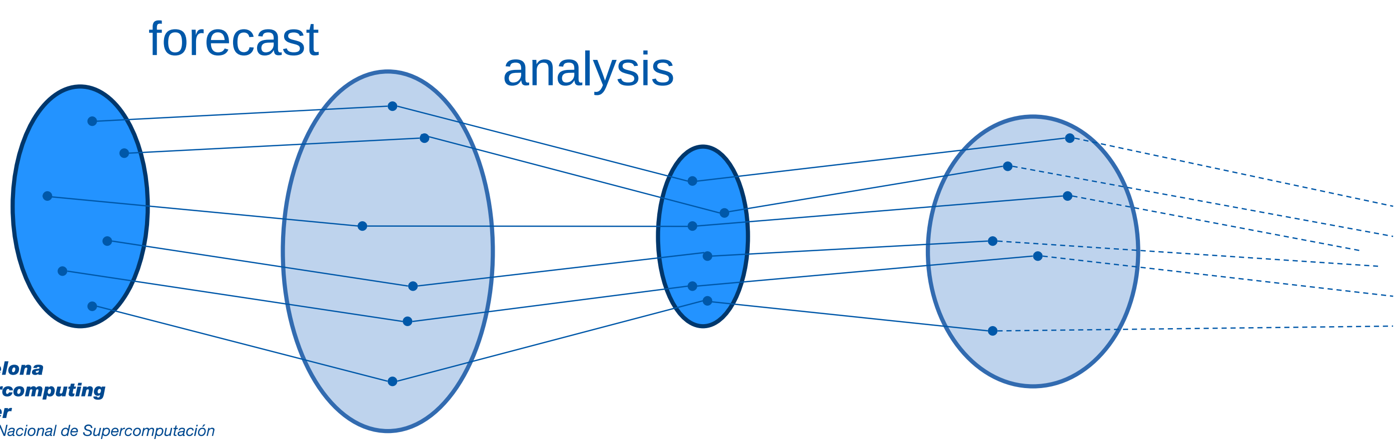
$$\mathbf{x}^a = \mathbf{x}^f + \mathbf{K}\,(\mathbf{d} - \mathbf{H}\,\mathbf{x}^f)$$

Analysis

Forecast
(NEMO-LIM2)

Kalman gain

Observations
Global, daily sea-ice **concentrations** (OSI-SAF)



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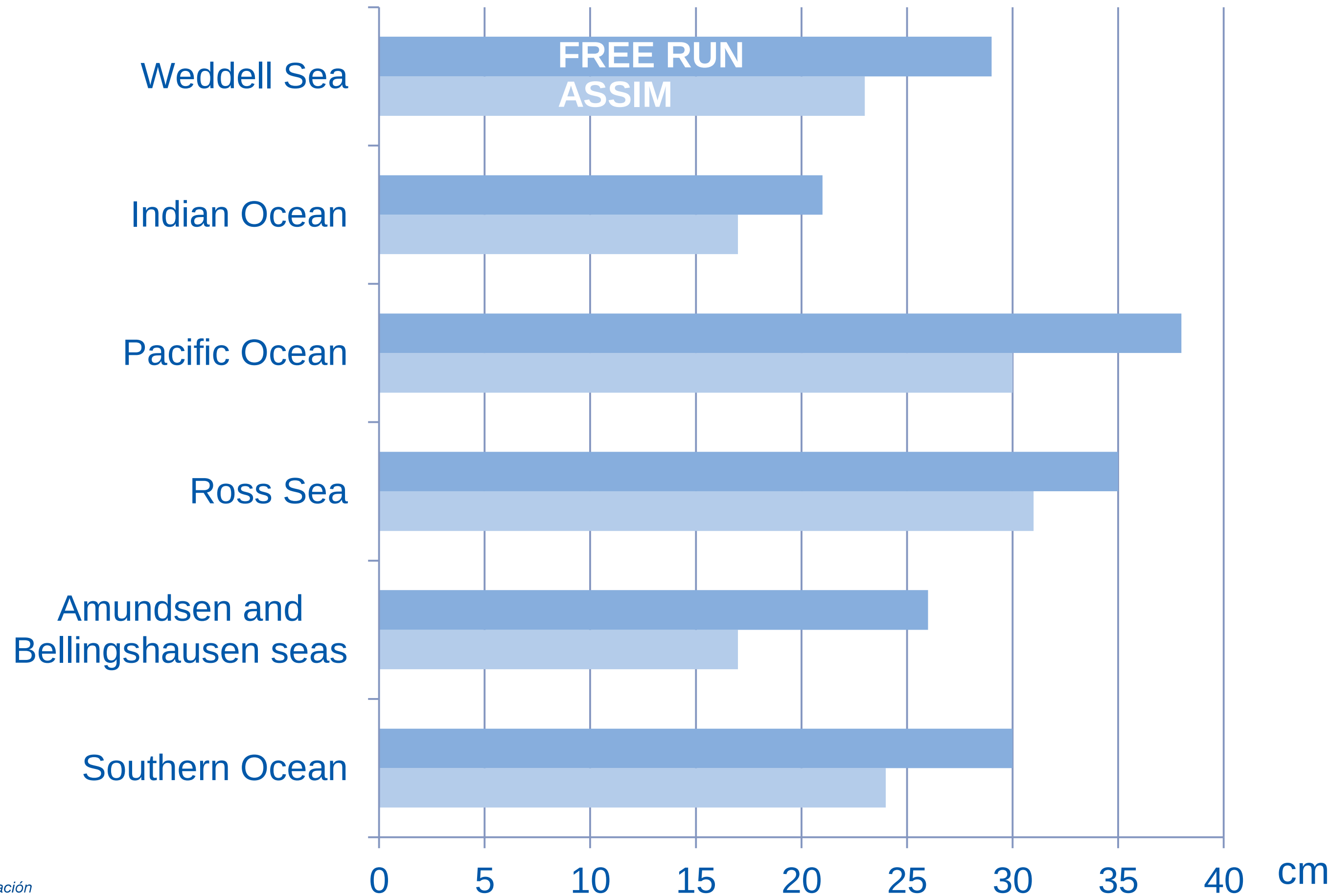
Mean **bias** in simulated thickness against ASPeCt data [Worby et al., 2008]



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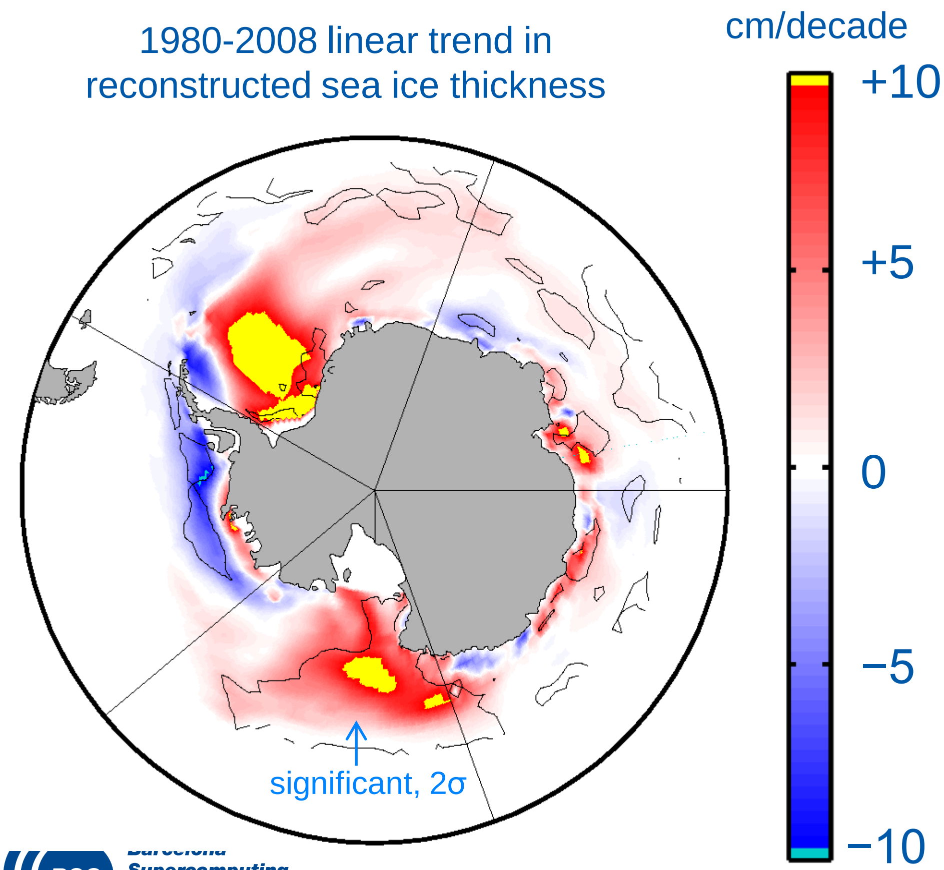
Trends in Southern Ocean sea ice thickness



The global increase in volume
should be analyzed
at the regional scale first

Regional signed responses
are a result of regional dynamical
and thermodynamical processes

[Holland et al., 2012; Bromwich et al., 2012;
Liu et al., 2004; Lefebvre and Goosse, 2008]

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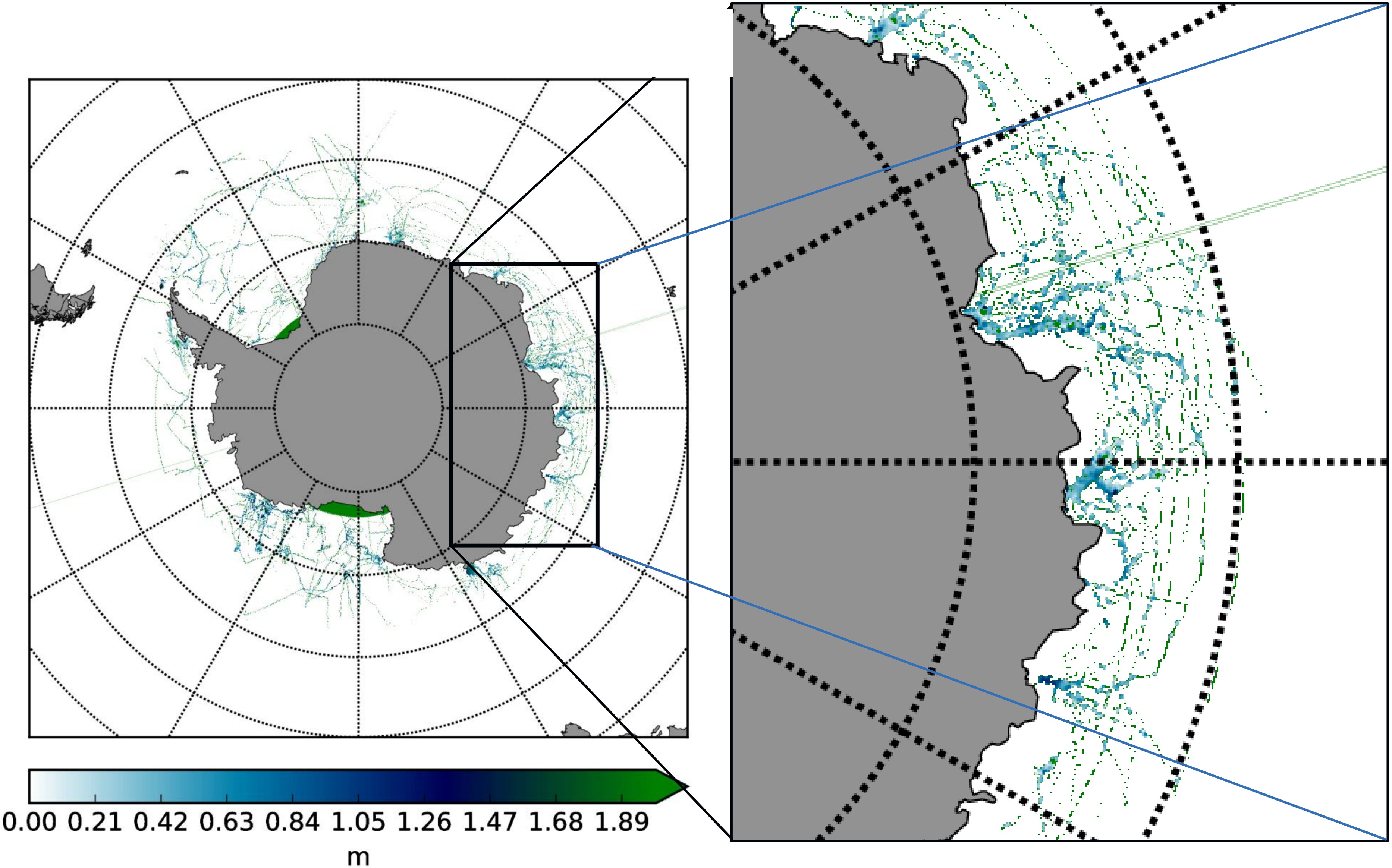
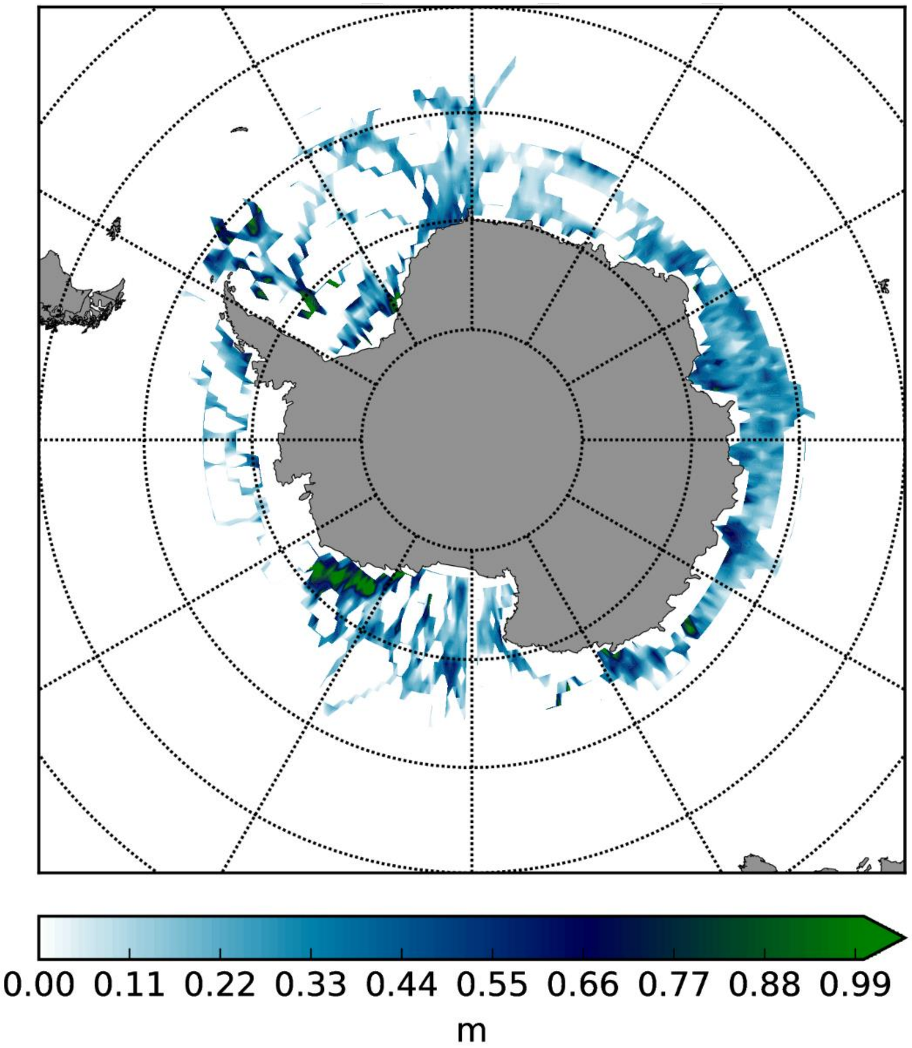
Along-track comparison of ASPeCt with ORAP5



Along-track comparison of ASPeCt with GECCO2



	ORAP5	GECCO-2	Massonnet et al. 2013
Mean bias	39 cm	31 cm	24 cm

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Evaluation of Southern Ocean currents

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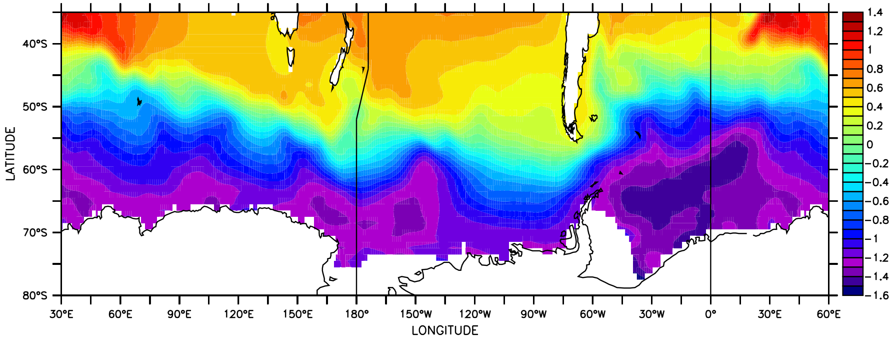
OSTM/Jason 2
(NOAA)
Aquarius
QuikSCAT
TRMM
Terra
ISS-RapidScat,
CATS
EO-1
SMAP
Landsat 7
(USGS)
Aqua
Suomi NPP
(NOAA)
Landsat 8
(USGS)
SORCE,
TCTE (NOAA)
Aura
GPM
GRACE (2)
CALIPSO
CloudSat
OCO-2

Satellite altimetry data

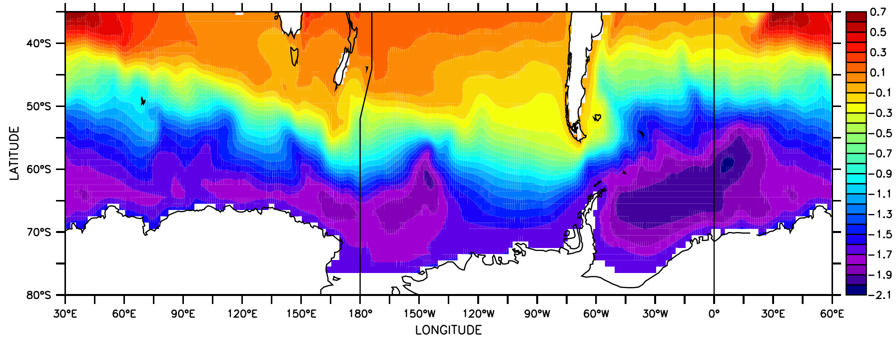
AVISO mean SSH (Jan 1993, Dec 2010)



https://podaac.jpl.nasa.gov/dataset/AVISO_L4_DYN_TOPO_1DEG_1MO
http://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products.html

NEMO3 + 3D-VAR FGAT mode

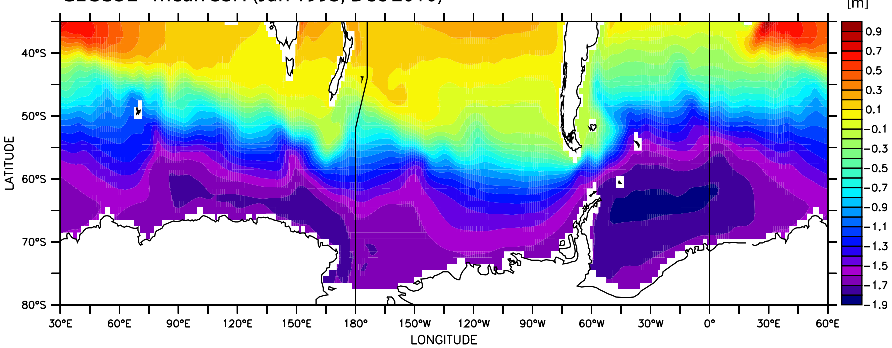
ORAS4 mean SSH (Jan 1993, Dec 2010)



http://www.ecmwf.int/en/research/climate-reanalysis/ocean-reanalysis
http://old.ecmwf.int/products/forecasts/d/charts/oras4/reanalysis/

MITgcm + 4D-VAR (adjoint)

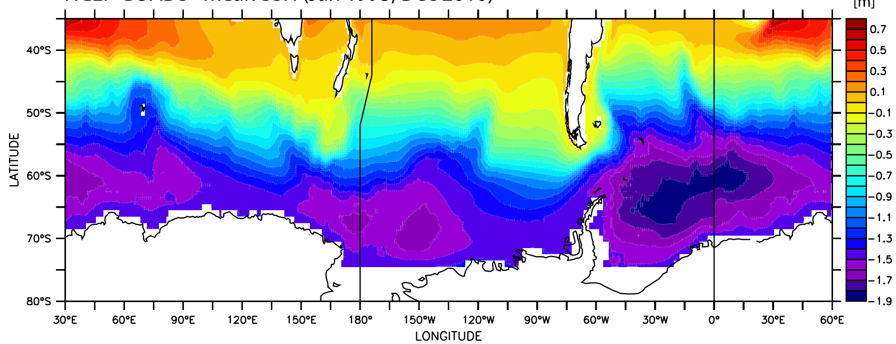
GECCO2 mean SSH (Jan 1993, Dec 2010)



http://icdc.zmaw.de/1/daten/reanalysis-ocean/gecco2.html

MOM3 + 3D-VAR

NCEP GOADS mean SSH (Jan 1993, Dec 2010)

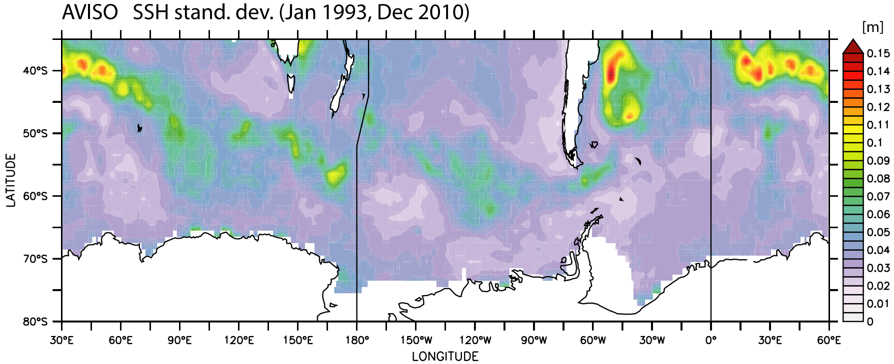


http://www.esrl.noaa.gov/psd/data/gridded/data.godas.html

Stand. Dev. of Sea Surface Height

Satellite altimetry data

AVISO SSH stand. dev. (Jan 1993, Dec 2010)



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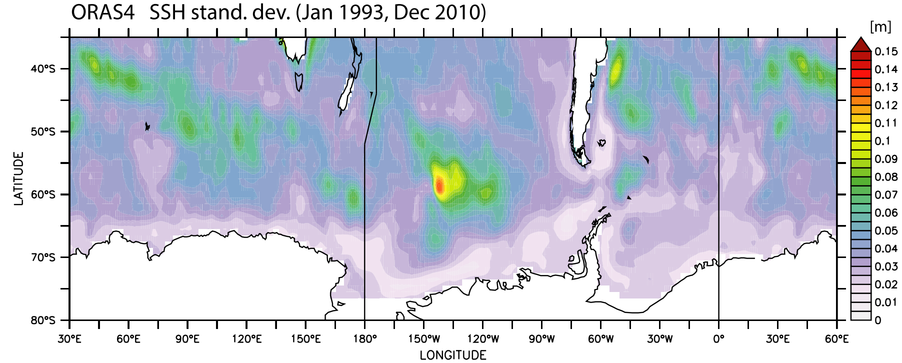
http://www.aviso.altimetry.fr/en/data/products/sea-surface-height-products.html

NEMO3 + 3D-VAR FGAT mode

ORAS4 SSH stand. dev. (Jan 1993, Dec 2010)



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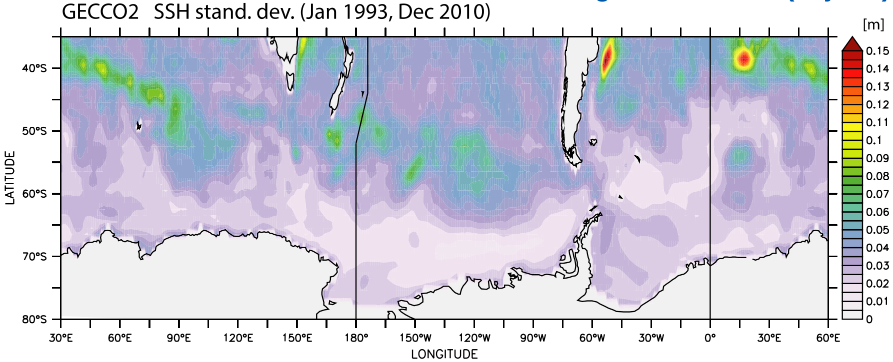

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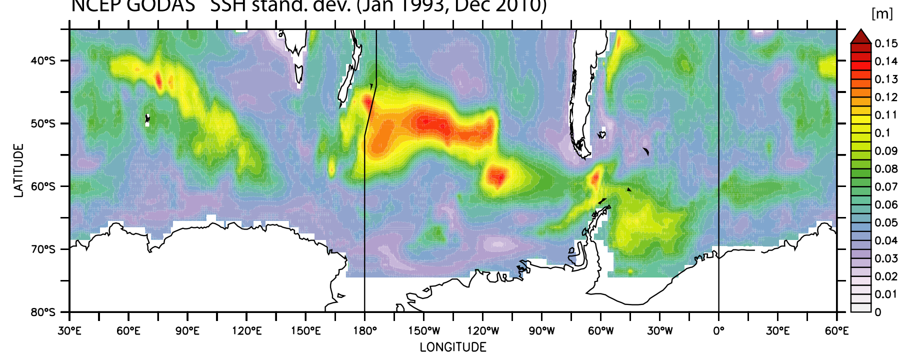
MOM3 + 3D-VAR

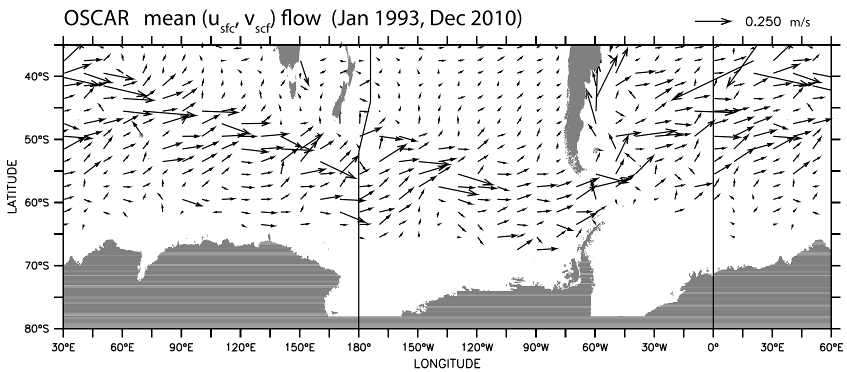
NCEP GODAS SSH stand. dev. (Jan 1993, Dec 2010)



http://www.esrl.noaa.gov/psd/data/gridded/data.godas.html

Mean Ocean Surface Velocity

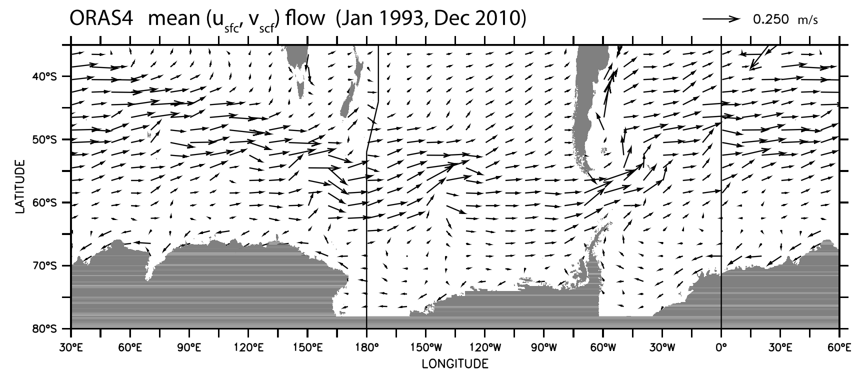
Satellite-derived surface velocity



http://www.oscar.noaa.gov/
http://podaac.jpl.nasa.gov/dataset/OSCAR_L4_OC_1deg

Ocean Surface Current Analysis – Real time (OSCAR)
→ global ocean surface currents derived from satellite altimeter and scatterometer data

NEMO3 + 3D-VAR FGAT mode



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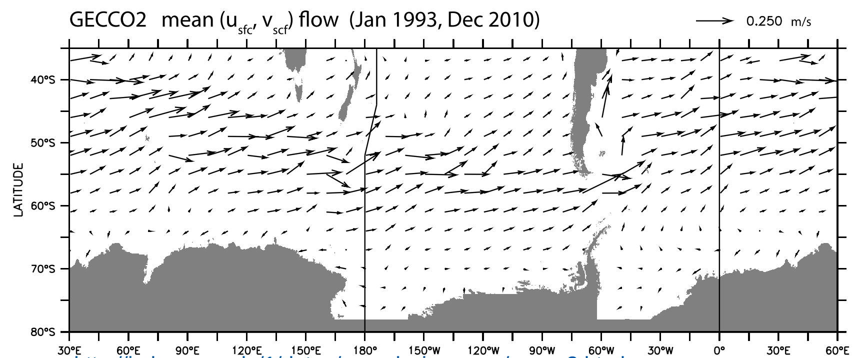

http://icdc.zmaw.de/1/daten/reanalysis-ocean/gecco2.html

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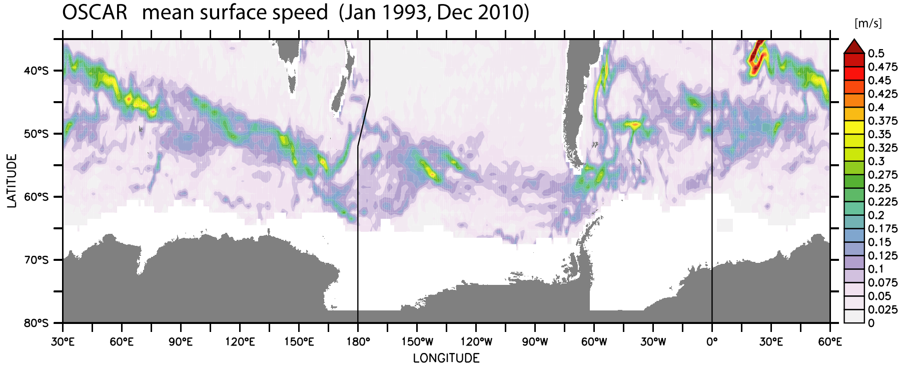
Mean Ocean Surface Speed

Satellite-derived surface speed



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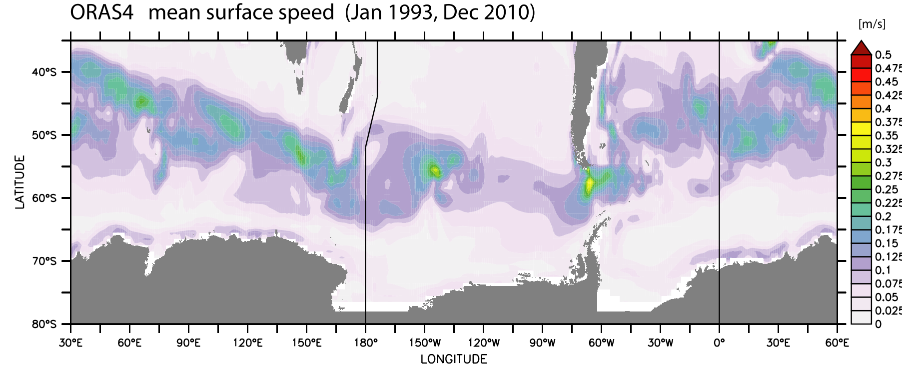

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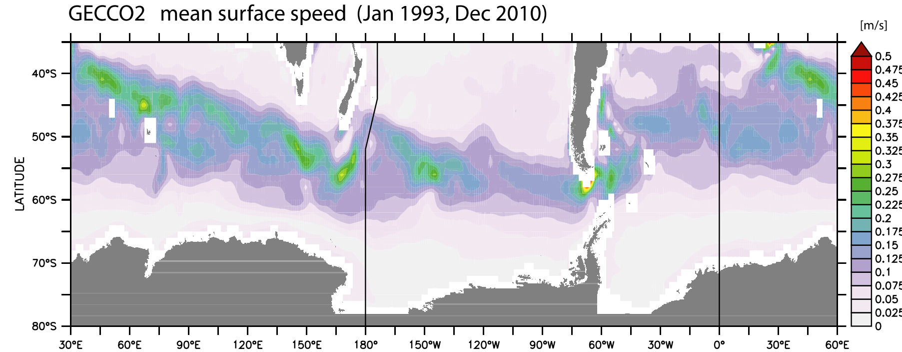

http://icdc.zmaw.de/1/daten/reanalysis-ocean/gecco2.html

Some thoughts to move forward

- Re-gridding will be necessary. To what grid?
- Need to define a proper metric for velocity (vector) assessment
- Need a comprehensive comparison table as e.g. in Chevallier et al. 2016 Clim. Dyn.
- Important to determine when and where spread of reanalyses is lower than mean bias
- To the extent of possible, relate bias to model characteristics

Thanks

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